



The State of the Arctic Environmental System

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O F F I C E O F N A V A L R E S E A R C H



Look Beyond Sea Ice

..... and you see change occurring throughout the Arctic environmental system.

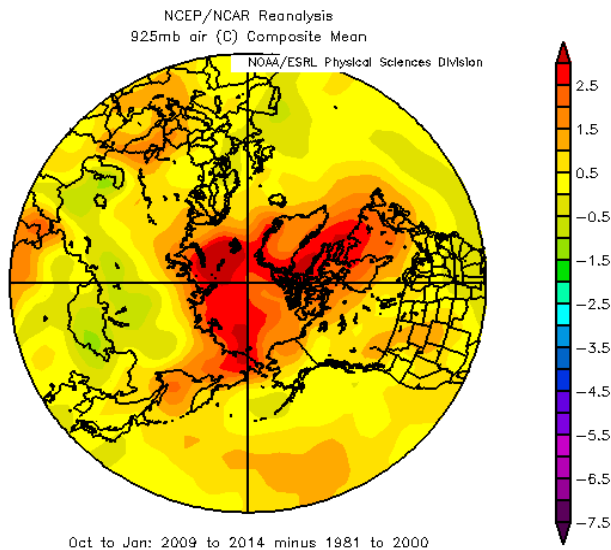
- Change is occurring on land, in the atmosphere and in the ocean.
- The changes are physical and biological.
- Arctic environmental change has global consequences.
- The “State of the Arctic” is reported annually in the **Arctic Report Card** (December) and in the **State of the Climate** report (July).
- **Arctic Report Card:** <http://www.arctic.noaa.gov/reportcard>
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Air Temperature

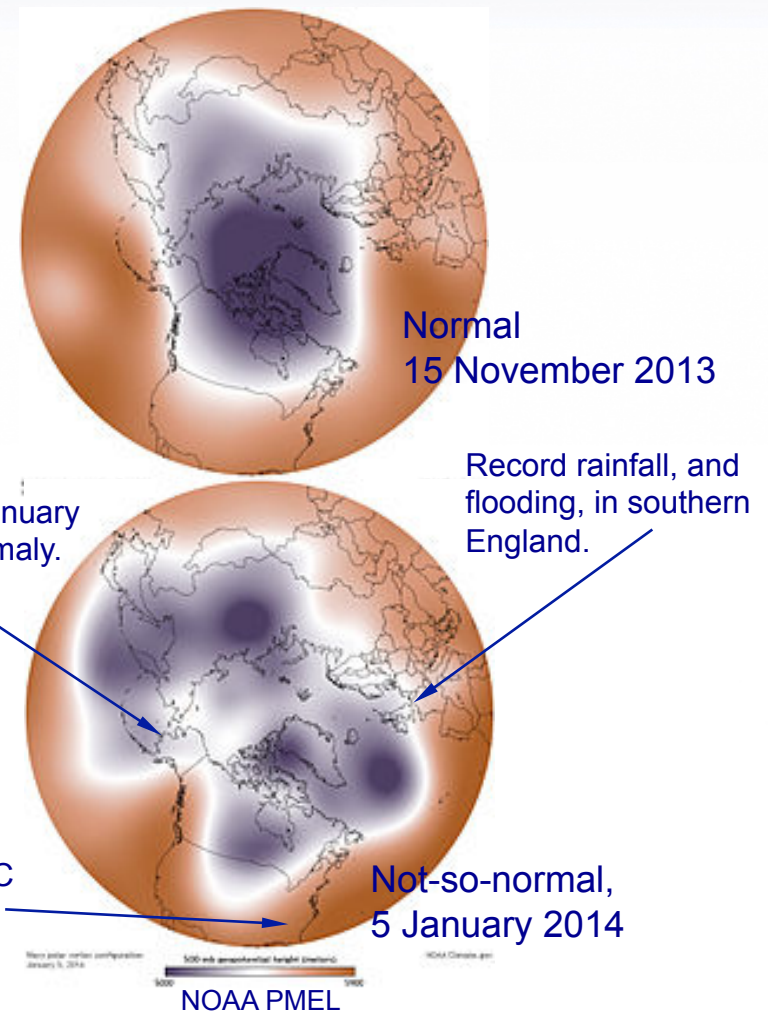
In 2014, the mean annual surface air temperature anomaly for Arctic lands was $+1.1^{\circ}\text{C}$ (relative to the 1981-2010 mean).

The rate of warming in the Arctic is $>2\times$ the rate of the rest of the World.



Autumn air temperature anomaly: early 21st Century vs. late 20th Century.

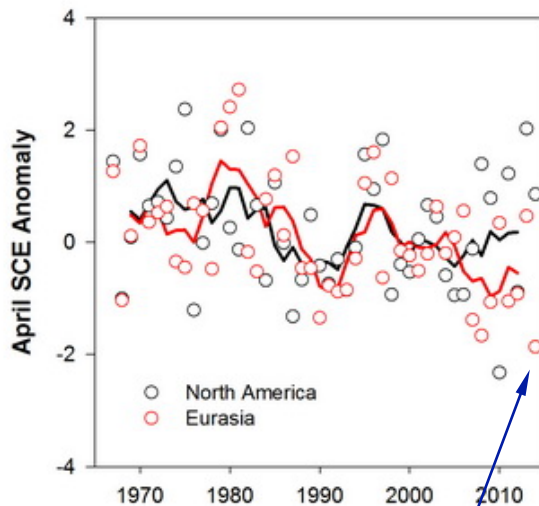
In early 2014, Arctic and mid-latitude weather patterns were strongly connected: **The Polar Vortex!!!!!!**



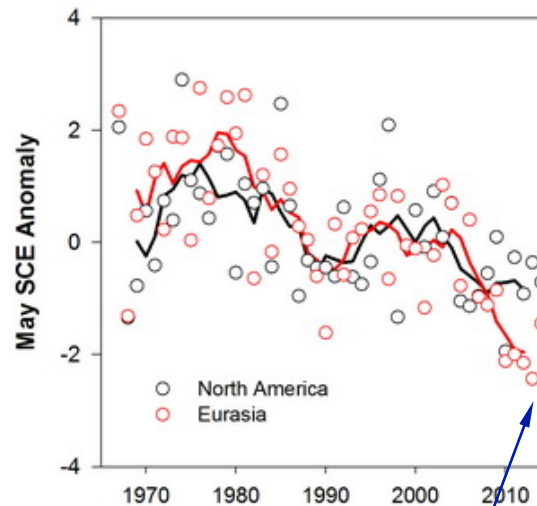


Terrestrial Snow Cover

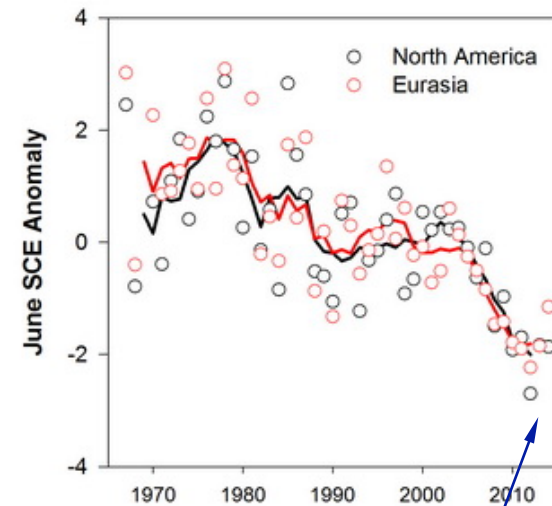
Spring Snow Cover Extent is declining in Eurasia & North America



Record low snow cover extent in April 2014 in Eurasia.



Below average snow cover extent in May 2014 in Eurasia and North America for the 9th time in the last 10 years.



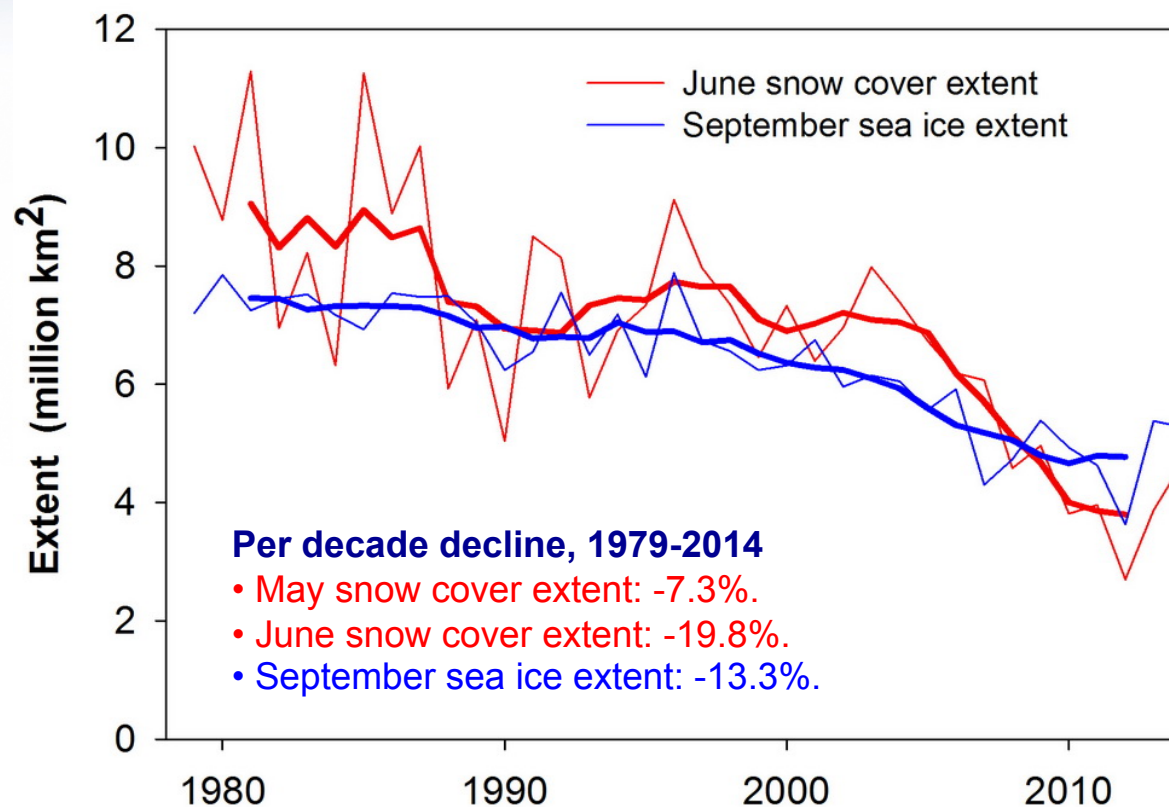
Below average snow cover extent in 2014 in Eurasia and North America for the 10th consecutive June.



Snow Cover & Sea Ice

Emerging evidence that Arctic warming is driving synchronous pan-Arctic responses in the terrestrial and marine cryosphere.

Why it matters.



The rates of decline in terrestrial snow cover extent in May and June bracket the rate of decline in September sea ice extent.

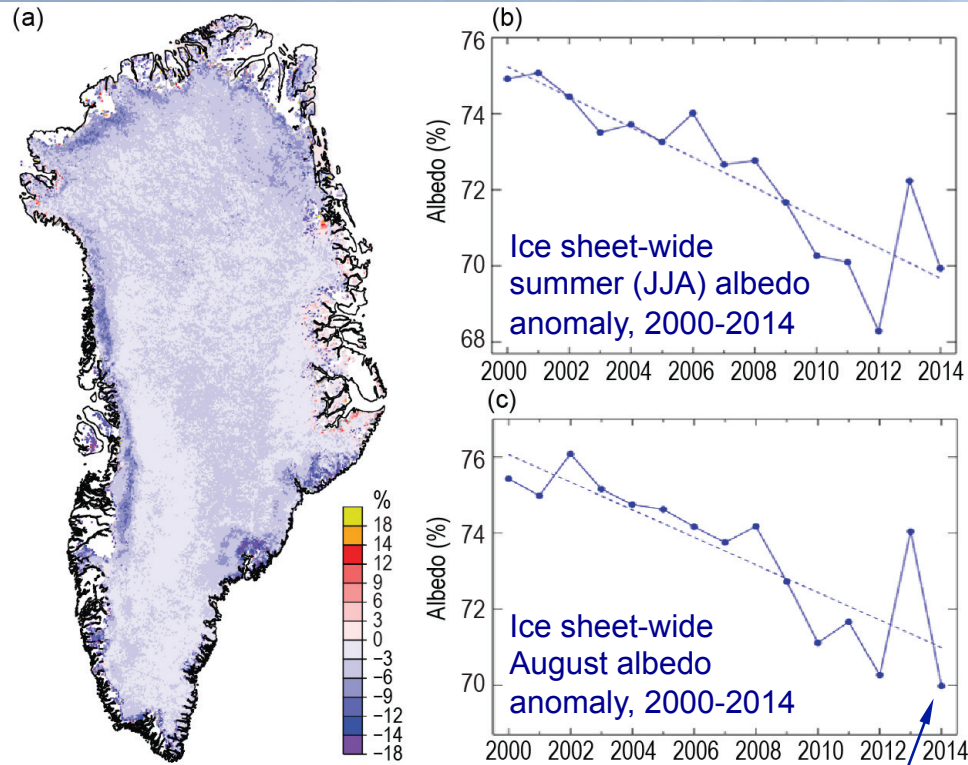
Albedo: 1

Albedo: 0



Don Perovich, CRREL

Greenland Ice Sheet

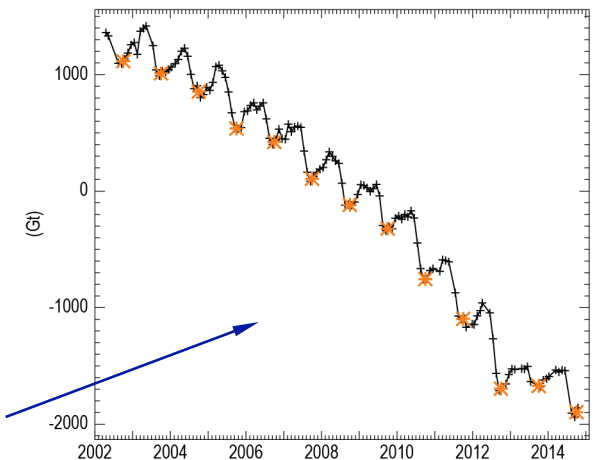
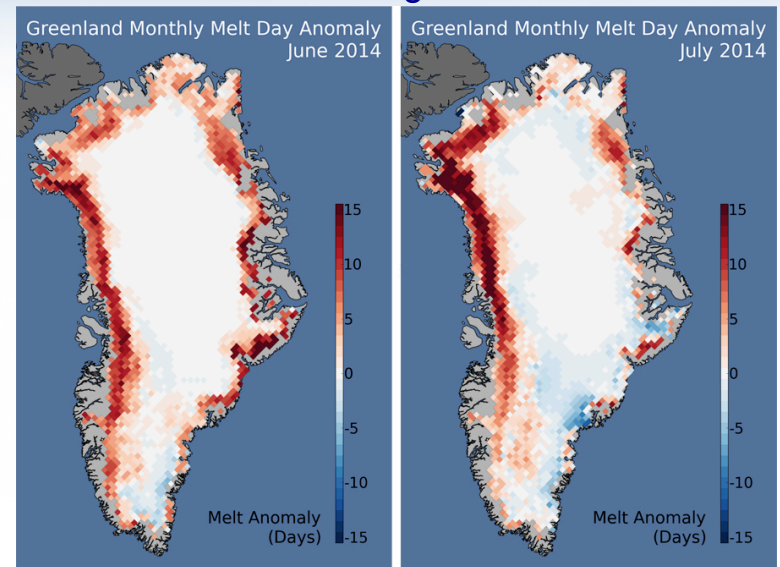


Summer 2014 albedo anomaly (relative to 2000-2011).

In 2014, a record low albedo for August.

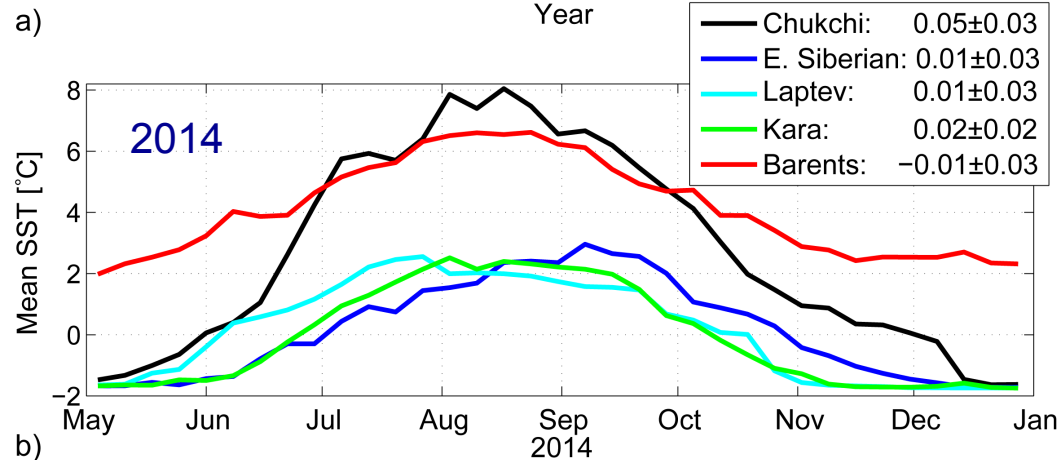
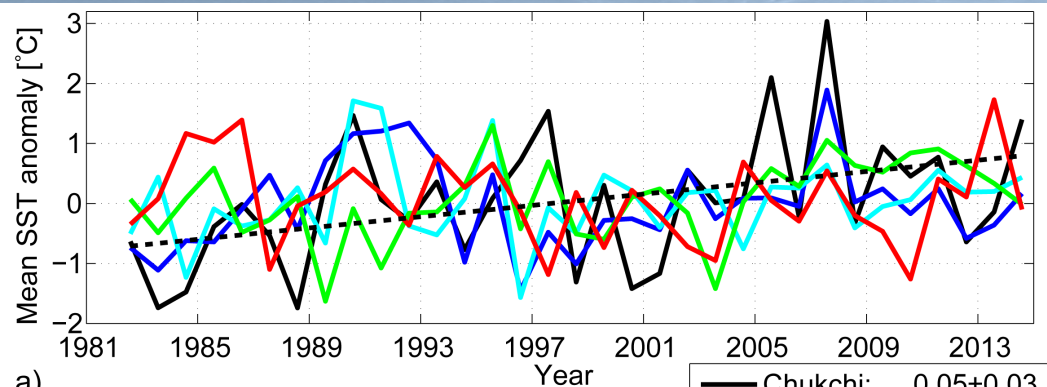
GRACE satellite measurements show that the total mass balance (ΔM , in gigatonnes) of the ice sheet has been declining since observations began in 2002.

No. of days with melting in June (L) and July (R) 2014. Anomaly relative to 1981-2010 average.

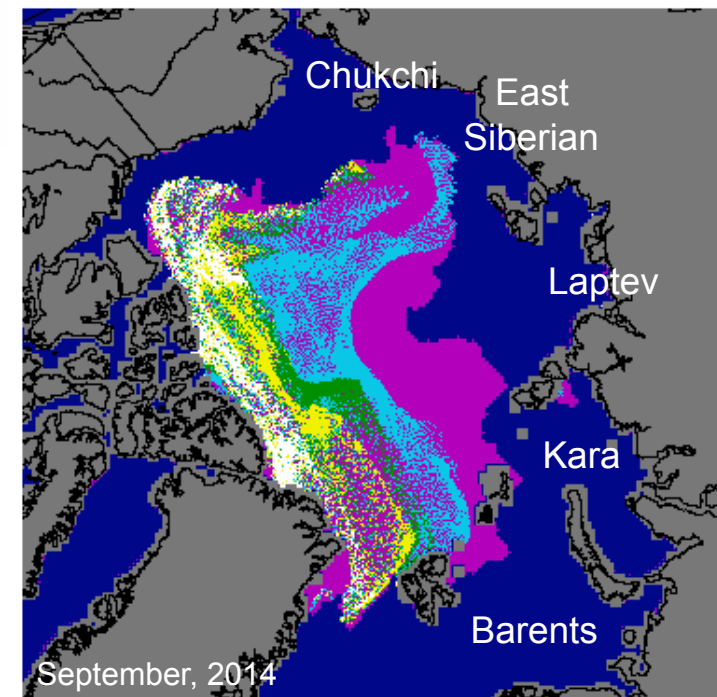
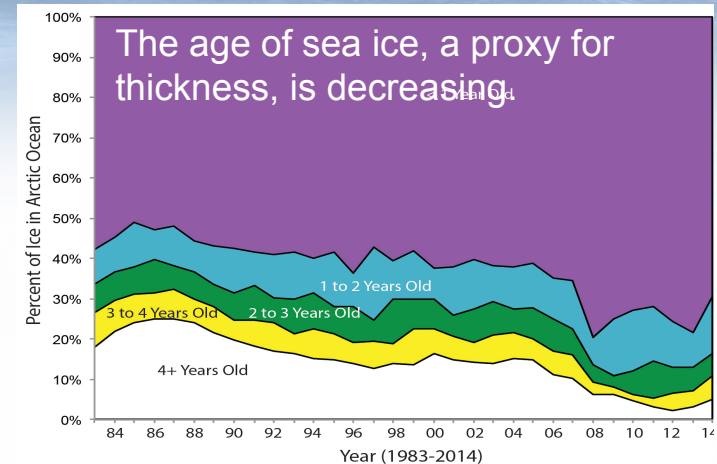




Sea Surface Temperature (SST)



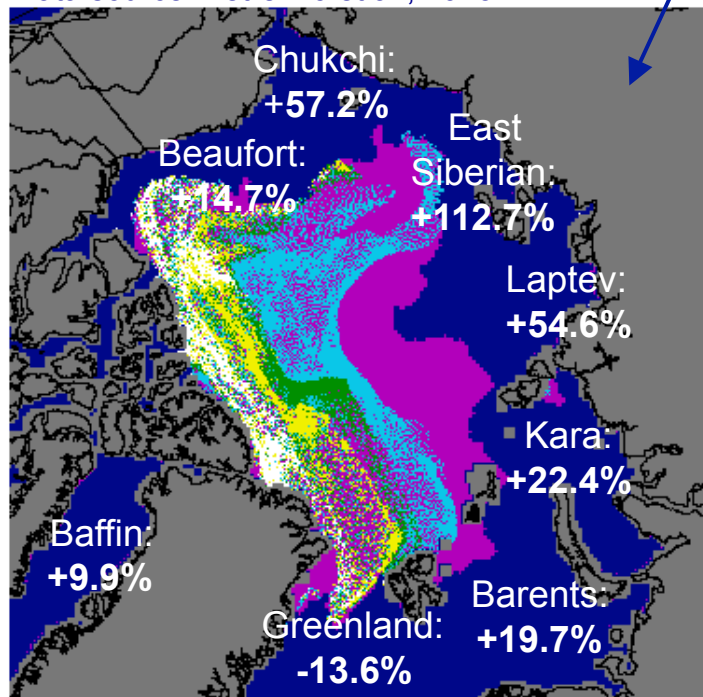
(a) SST is increasing, with the most significant trend occurring in the Chukchi Sea ($+0.5^{\circ}\text{C}$ per decade during 1982-2010). (b) In 2014, SST was highest in the Chukchi and Barents seas, reflecting the timing and rate of ice retreat.



Ocean Primary Production

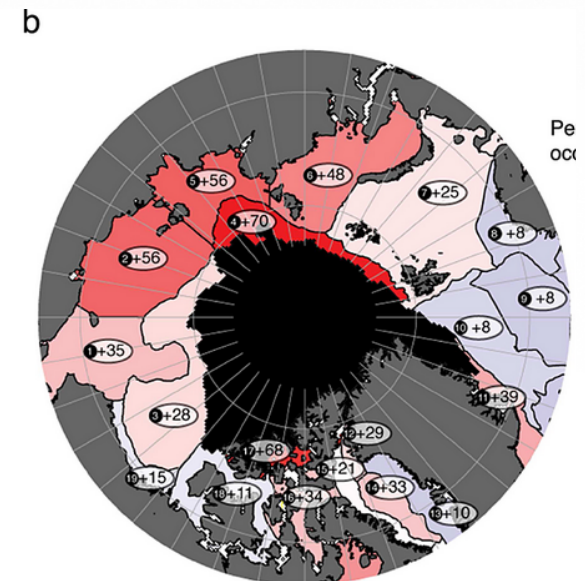
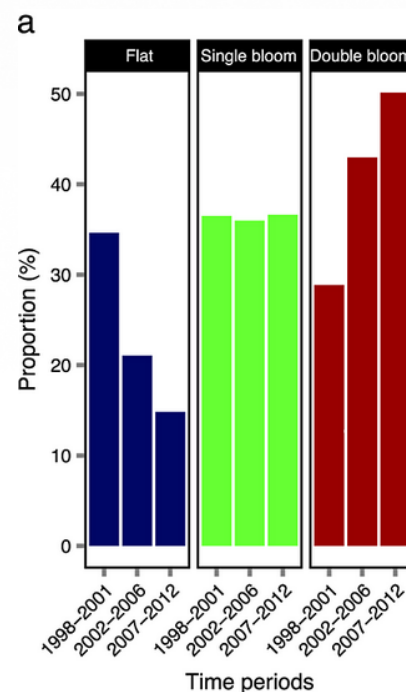
Primary production: The conversion, primarily by photosynthesis, of atmospheric or aqueous CO₂ to organic matter. In the ocean, almost all photosynthesis is by algae, and in the Arctic it is dependent on ice retreat, light and nutrients. Arctic Ocean primary production is increasing.

Data source: Petrenko et al., 2013



Change in primary production, 1998-2010. Arctic-wide $\Delta = +15.9\%$.

NSIDC courtesy M. Tschudi, University of Colorado Boulder

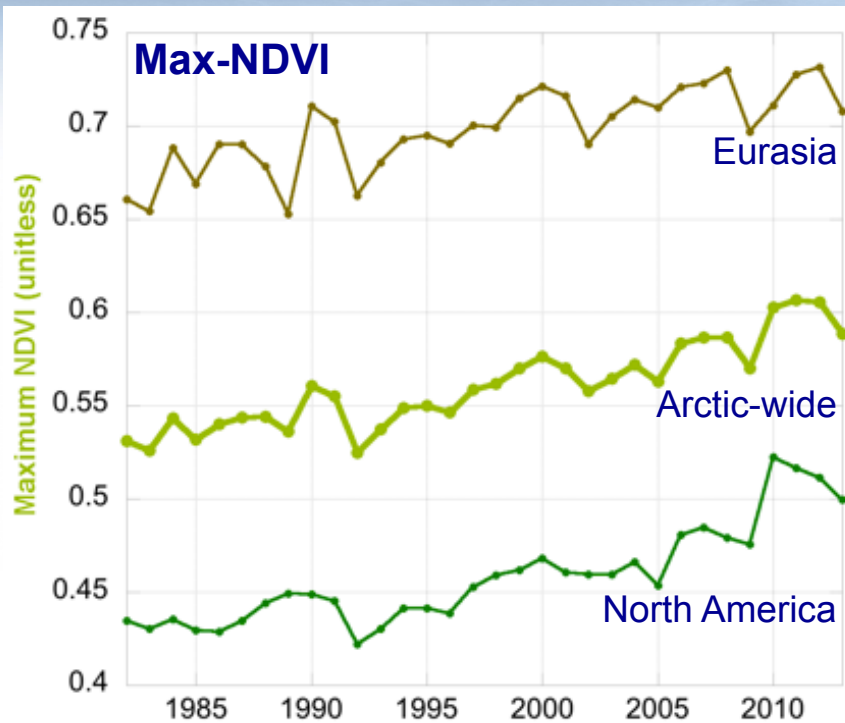


The timing of primary production is changing, with a shift to secondary blooms in the autumn. Reason: extended open water season, autumn storms, upper ocean mixing and increased nutrient availability.

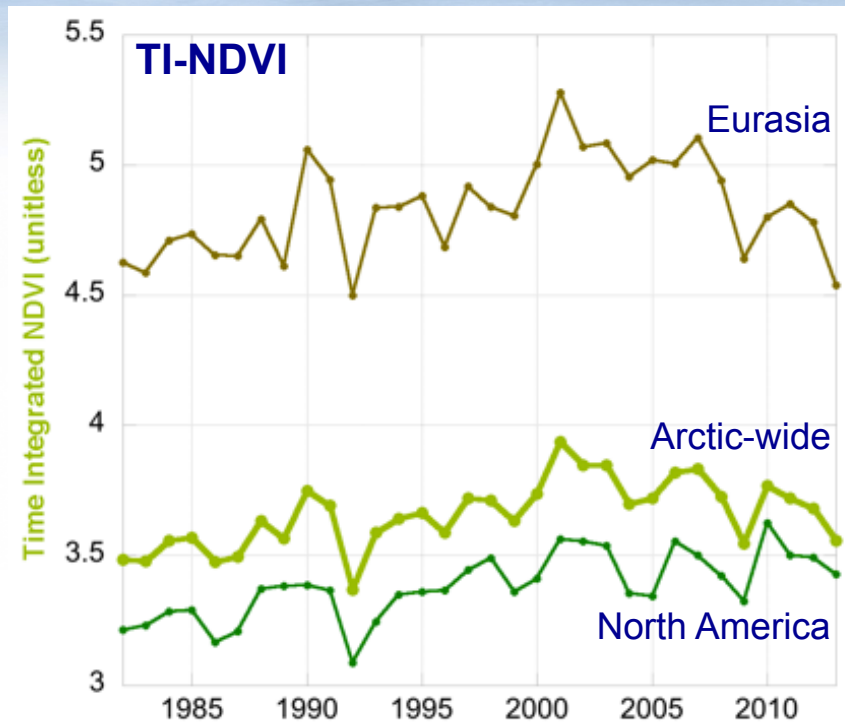


Tundra Greenness

(Normalized Difference Vegetation Index: NDVI)



Arctic-wide, Maximum (Max)-NDVI, which is strongly correlated with above-ground biomass, increased ~20% between 1982 and 2013, equivalent to a biomass increase from ~357 g m⁻² to 430 g m⁻².



NDVI integrated over the entire growing season (TI-NDVI) increased (greening) until ~2000, then began to decline (browning). Reasons: decrease in growing season length due to permafrost degradation and hydrological change; declining summer air temperature in Eurasia.



Summary

Change is occurring throughout the Arctic environmental system. It's not all about sea ice.

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